Numerical Simulation of the Rate of Dross Formation in Continuous Galvanizing Baths

Among the many challenges of the numerical simulation of the process of continuous galvanizing of steel sheet, the generation of dross particles is one of the most critical considerations. The presence of dross particles in different sections of a typical galvanizing bath is determined by both operational and configurational parameters that affect the nature of the flow, the temperature, and the distribution of the dissolved Al and Fe and of precipitated $Fe_3Zn_{24}Al_x$ (bottom dross) or $Fe_2Al_5Zn_x$ (top dross) particles. In order to quantify the effect of the flow field, temperature and concentration variations, the numerical simulation must take into account the physical and geometrical boundary conditions, the thermodynamics of the solution, as well as the industrially obtained data for iron dissolution from the strip, the rate of ingot melting and the rate of deposition of the coating.

Three-dimensional computer simulations have been carried out in a series of ILZRO-sponsored research projects and have been presented in several publications[1–3] for a typical bath configuration. Simulations were performed using the IMI in-house CFD software adapted for the solution of the heat and mass transfer, including the k-ε model of turbulence and buoyancy effects. The results of these simulations show the spatial distribution of temperature and composition of Fe and Al over a two-hour cycle with typical additions of ingots as required to maintain an overall heat and mass balance at the end of the two-hour period.

The present study compares the simulations of the standard configuration and operations with new operational and configurational parameters using a model for the entire bath volume, since the configurational parameters include asymmetric configurations. Other parameters that are considered are bath size, strip entry temperature, Al content of the ingot, gradual ingot immersion, as well as galvanize and galvanneal operations. The objective of this study is to carry out numerical simulations for flow, heat and mass transfer in order to determine the amount of dross particles generated within the liquid bath for a number of operational and geometric configurations as compared to a standard reference operating condition.

The rate of dross formation for 19 different conditions was calculated for a two-hour cycle. Differences in the evolution of the amount of dross formed in the galvanizing bath over this period were analyzed. The results can be used to provide guidelines for bath operation to minimize dross formation and accumulation.

Methodology

Figure 1 is a schematic of a typical modern galvanizing bath heated with two side inductors and with ingot melting at the center of the back wall of the bath. The basic bath configuration is given in Table 1, corresponding to a 250-ton bath and a deposition rate of 60 g/m^2 per side. It was previously established that ingot melting (complete immersion) takes 20 minutes and, at the deposition rate specified, an ingot is added at 60-minute intervals.[4] The inductors operate at maximum power during melting and at 20 percent of the maximum power during the period when no ingot is present, compensating for the heat loss from the bath. Under these conditions, an ingot containing 0.50 percent Al is added every hour, and the Fe and Al content at the end of

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